DESCRIPTION

HEAT TRENSFER FIN, HEAT EXCHANGER, EVAPORATOR AND CONDENSER FOR USE IN CAR AIR-CONDITIONER

Priority is claimed to Japanese Patent Application No. 2003-15045, filed on January 23, 2003, and U.S. Provisional Application No.60/454,525, filed on March 14, 2003, the disclosure of which are incorporated by reference in their entireties.

Cross Reference to Related Applications

This application is an application filed under 35 U.S.C. § 111(a) claiming the benefit pursuant to 35 U.S.C. § 119(e)(1) of the filing date of U.S. Provisional Application No.60/454,525, filed on March 14, 2003 pursuant to 35 U.S.C. § 111(b).

Technical Field

The present invention relates to a heat transfer fin for heat exchangers such as evaporators or condensers for use in car air-conditioners, and also relates to a heat exchanger, an evaporator for use in car air-conditioners or a condenser for use in car air-conditioners using such heat transfer fins.

Background Art

The following description sets forth the inventor's knowledge of related art and problems therein and should not be construed as an admission of knowledge in the prior art.

It is well known that an evaporator and the like for use in car air-conditioners includes a plurality of heat exchanging tubes disposed in parallel with each other and a plurality of thin-plate like fins as heat transfer plates disposed between the adjacent heat exchanging tubes and arranged in parallel at certain intervals along the tube longitudinal direction.

In such an evaporator, an air passage is formed between adjacent fins, and heat exchanging is performed between the air passing through the air passage and the refrigerant passing through the heat exchanging tubes via the fins.

In the evaporator, it is considered that increasing the fin pitch is one of the effective ways for improving the thermal performance.

However, as shown in Fig. 14, in a conventional fin 100, since the cross-sectional contour of the windward side end thereof is formed into a rectangular shape, the windward side end face 101 is constituted as a nearly vertical surface against the air A passing through the air passage 110. As a result, when the air A collides with the windward side end face 101, turbulence of the air A occurs. Accordingly, increasing the fin pitch causes increased turbulence of the air A, resulting in an increased pressure loss. This increased pressure loss deteriorates the inhale amount of the air A and the inhale velocity of the air A, which in turn may result in deteriorated heat exchanging performance.

In other words, when two heat transfer fins each having the same heat transfer rate are compared, the heat exchanger having a larger pressure loss is lower in performance, and the heat exchanger

having a smaller pressure loss is higher in performance and therefore excellent in heat exchanging performance.

Under the circumstances, for example, Japanese Unexamined Laid-open Patent Publication No. 60-82786 discloses a fin-and-tube type heat exchanger in which the leeward side edge of the heat transfer fin is formed to be thin to decrease the pressure loss (see Figs. 2 and 3).

According to the heat transfer fin shown in the aforementioned document, the pressure loss can be decreased to some extent.

However, in the recent heat exchanger technical field, a further improvement of heat exchanging performance is required, and therefore a still further decreased pressure loss and improved heat transfer rate are desired.

The description herein of advantages and disadvantages of various features, embodiments, methods, and apparatus disclosed in other publications is in no way intended to limit the present invention. Indeed, certain features of the invention may be capable of overcoming certain disadvantages, while still retaining some or all of the features, embodiments, methods, and apparatus disclosed therein.

It is an object of the present invention to provide a heat transfer fin capable of improving heat transfer rate while decreasing pressure loss to thereby obtain excellent heat exchanging performance.

It is another object of the present invention to provide a heat exchanger using the aforementioned heat transfer fins.

It is still another object of the present to provide an

evaporator for use in car air-conditioners using the aforementioned heat transfer fins.

It is still yet another object of the present invention to provide a condenser for use in car air-conditioners using the aforementioned heat transfer fins.

Other objects and advantages of the present invention will be apparent from the following preferred embodiments.

Disclosure of Invention

The first aspect of the present invention employs the following structure (1).

(1) A heat transfer fin, comprising:

a heat transfer plate for transferring heat of a heat transfer medium via the heat transfer plate, the heat transfer plate being disposed parallel or nearly parallel to a flowing direction of the heat transfer medium,

wherein a heat transfer medium inlet side edge of the heat transfer plate is formed so as to become thinner toward an upstream side of a heat transfer medium flowing direction.

In the heat transfer plate according to the first aspect of the present invention, since the heat transfer medium inlet side edge of the heat transfer plate is formed so as to become thinner toward an upstream side of a heat transfer medium flowing direction, the heat transfer medium flows smoothly along the external surface of the heat transfer plate without causing turbulence. Thus, the flow resistance of the heat transfer medium decreases, causing a decreased pressure loss, which in turn results in an enhanced heat

transfer rate. As a result, excellent heat exchanging performance can be obtained.

In the first aspect of the present invention, it is preferable to employ the following structure (2).

(2) The heat transfer fin as recited in the aforementioned Item (1), wherein a heat transfer medium outlet side edge of the heat transfer plate is formed so as to become thinner toward a downstream side of the heat transfer medium flowing direction.

In this heat transfer fin, the pressure loss can be further decreased, resulting in a further enhanced heat transfer rate.

The second aspect of the present invention employs the following structure (3).

(3) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed in parallel with each other at certain intervals to form an air passage between adjacent heat transfer plates, whereby heat of air passing through the air passage is transferred via the heat transfer plates,

wherein a windward side edge of the heat transfer plate is formed so as to become thinner toward a windward side of the air.

In this heat transfer fin according to the second aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the second aspect of the present invention, it is preferable to employ the following structures (4) and (5).

(4) The heat transfer fin as recited in the aforementioned Item (3), wherein the plurality of heat transfer fins are disposed

independently as plate fins.

(5) The heat transfer fin as recited in the aforementioned Item (3), wherein the plurality of heat transfer fins are connected such that adjacent heat transfer fins are connected to form a corrugated fin.

The third aspect of the present invention employs the following structure (6).

(6) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed between a pair of heat exchanging tubes arranged in parallel at a certain distance, the plurality of heat exchanging plates being disposed in parallel with each other at certain intervals along a longitudinal direction of the heat exchanging tube to form an air passage between adjacent heat transfer plates, whereby air passing through the air passage exchanges heat with refrigerant passing through the heat exchanging tubes,

wherein a windward side edge of the heat transfer plate is formed so as to become thinner toward a windward side thereof.

In this heat transfer fin according to the third aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the third aspect of the present invention, it is preferable to employ the following structures (7) to (9).

(7) The heat transfer fin as recited in the aforementioned Item (6), wherein the plurality of heat transfer plates are disposed independently as plate fins.

(8) The heat transfer fin as recited in the aforementioned Item (6), wherein the plurality of heat transfer plates are connected such that adjacent heat transfer fins are connected to form a corrugated fin.

(9) The heat transfer fin as recited in the aforementioned Item (6), wherein the plurality of heat transfer plates are integral skived fins formed by skiving a surface of the heat exchanging tube.

In the second and third aspects of the present invention, it is preferable to employ the following structures (10) to (15).

(10) The heat transfer fin as recited in any one of the aforementioned Items (3) to (9), wherein a cross-sectional contour configuration of the windward side edge of the heat transfer plate is formed into a curved configuration.

(11) The heat transfer fin as recited in any one of the aforementioned Item (10), wherein a cross-sectional contour configuration of the windward side edge of the heat transfer plate is formed into a semielliptic configuration.

(12) The heat transfer fin as recited in any one of the aforementioned Item (10), wherein a cross-sectional contour configuration of the windward side edge of the heat transfer plate is formed into a semicircular configuration.

(13) The heat transfer fin as recited in any one of the aforementioned Items (3) to (9), wherein a cross-sectional contour configuration of the windward side edge of the heat transfer plate is formed into a polygonal configuration.

(14) The heat transfer fin as recited in the aforementioned Item (13), wherein the cross-sectional contour configuration of the

windward side edge of the heat transfer plate is formed into a triangular configuration with an acute-angled tip.

(15) The heat transfer fin as recited in any one of the aforementioned Item (3) to (14), wherein a leeward side edge of the heat transfer plate is formed so as to become thinner toward a leeward side of the air.

The fourth aspect of the present invention employs the following structure (16).

(16) A heat transfer fin, comprising:

a heat transfer plate disposed parallel or nearly parallel to a heat transfer medium passing direction, the heat transfer plate being provided with a plurality of louvers at certain intervals along the heat transfer medium passing direction to transfer heat of the heat transfer medium via the heat transfer plate,

wherein a heat transfer medium inlet side edge of the louver is formed so as to become thinner toward an upstream side of the heat transfer medium passing direction.

In the heat transfer plate according to the fourth aspect of the present invention, since the heat transfer medium inlet side edge of the louver is formed so as to become thinner toward an upstream side of a heat transfer medium flowing direction, the heat transfer medium flows smoothly along the external surface of the louver without causing turbulence. Thus, the flow resistance of the heat transfer medium decreases, causing a decreased pressure loss, which in turn results in an enhanced heat transfer rate. As a result, excellent heat exchanging performance can be obtained.

In the fourth aspect of the present invention, it is preferable

to employ the following structure (17).

(17) The heat transfer fin as recited in the aforementioned Item (16), wherein a heat transfer medium outlet side edge of the heat transfer plate is formed so as to become thinner toward a downstream side of the heat transfer medium passing direction.

The fifth aspect of the present invention employs the following structure (18).

(18) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed in parallel with each other at certain intervals to form an air passage between adjacent heat transfer plates, the heat transfer plate being provided with a plurality of louvers at certain intervals along the air passage to transfer heat of air passing through the air passage via the heat transfer plate,

wherein a windward side edge of the louver is formed so as to become thinner toward an upstream side of the air.

In this heat transfer fin according to the fifth aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the fifth aspect of the present invention, it is preferable to employ the following structure (19).

(19) The heat transfer fin as recited in the aforementioned Item (18), wherein the plurality of heat transfer fins are connected such that adjacent heat transfer fins are connected to form a corrugated fin.

The sixth aspect of the present invention employs the

following structure (20).

(20) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed between a pair of heat exchanging tubes arranged in parallel at a certain distance, the plurality of heat transfer plates being disposed in parallel with each other at certain intervals along a longitudinal direction of the heat exchanging tube to form an air passage between adjacent heat transfer plates, and the heat transfer plate being provided with a plurality of louvers at certain intervals along the air passage, whereby air passing through the air passage exchanges heat with refrigerant passing through the heat exchanging tubes,

wherein a windward side edge of the louver is formed so as to become thinner toward a windward side of the air.

In this heat transfer fin according to the sixth aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the sixth aspect of the present invention, it is preferable to employ the following structure (21).

(21) The heat transfer fin as recited in the aforementioned Item (20), wherein the plurality of heat transfer fins are connected such that adjacent heat transfer fins are connected to form a corrugated fin.

In the fifth and sixth aspects of the present invention, it is preferable to employ the following structures (22) to (27).

(22) The heat transfer fin as recited in any one of the aforementioned Items (18) to (21), wherein a cross-sectional contour

configuration of the windward side edge of the louver is formed into a curved configuration.

(23) The heat transfer fin as recited in the aforementioned Item (22), wherein a cross-sectional contour configuration of the windward side edge of the louver is formed into a semielliptic configuration.

(24) The heat transfer fin as recited in the aforementioned Item (22), wherein a cross-sectional contour configuration of the windward side edge of the louver is formed into a semicircular configuration.

(25) The heat transfer fin as recited in any one of the aforementioned Items (18) to (21), wherein a cross-sectional contour configuration of the windward side edge of the louver is formed into a polygonal configuration.

(26) The heat transfer fin as recited in the aforementioned Item (25), wherein the cross-sectional contour configuration of the windward side edge of the louver is formed into a triangular configuration with an acute-angled tip.

(27) The heat transfer fin as recited in any one of the aforementioned Items (18) to (26), wherein a leeward side edge of the louver is formed so as to become thinner toward a leeward side of the air.

The seventh aspect of the present invention employs the following structure (28).

(28) A heat transfer fin, comprising:

a heat transfer plate disposed parallel or nearly parallel to a heat transfer medium passing direction, the heat transfer plate

being provided with a plurality of louvers at certain intervals along the heat transfer medium passing direction to transfer heat of the heat transfer medium via the heat transfer plate,

wherein a heat transfer medium inlet side edge of the heat transfer plate and that of the louver are respectively formed so as to become thinner toward an upstream side of the heat transfer medium passing direction.

In the heat transfer plate according to the seventh aspect of the present invention, since the heat transfer medium inlet side edge of the heat transfer plate and that of the louver are respectively formed so as to become thinner toward an upstream side of a heat transfer medium flowing direction, the heat transfer medium flows smoothly along the external surface of the heat transfer plate and that of the louver without causing turbulence. Thus, the flow resistance of the heat transfer medium decreases, causing a decreased pressure loss, which in turn results in an enhanced heat transfer rate. As a result, excellent heat exchanging performance can be obtained.

In the seventh aspect of the present invention, it is preferable to employ the following structure (29).

(29) The heat transfer fin as recited in the aforementioned Item (28), wherein at least one of heat transfer medium outlet side edges of the heat transfer plate and the louver is formed so as to become thinner toward a downstream side of the heat transfer medium passing direction.

The eighth aspect of the present invention employs the following structure (30).

(30) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed in parallel with each other at certain intervals to form an air passage between adjacent heat transfer plates, the heat transfer plate being provided with a plurality of louvers at certain intervals along the air passage to transfer heat of air passing through the air passage via the heat transfer plate,

wherein a windward side edge of the heat transfer plate and that of the louver are respectively formed so as to become thinner toward an upstream side of the air.

In this heat transfer fin according to the eighth aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the eighth aspect of the present invention, it is preferable to employ the following structure (31).

(31) The heat transfer fin as recited in the aforementioned Item (30), wherein at least one of leeward side edges of the heat transfer plate and the louver is formed so as to become thinner toward a leeward side of the air.

The ninth aspect of the present invention employs the following structure (32).

(32) A heat transfer fin, comprising:

a plurality of heat transfer plates disposed between a pair of heat exchanging tubes arranged in parallel at a certain distance, the plurality of heat exchanging plates being disposed in parallel with each other at certain intervals along a longitudinal direction

of the heat exchanging tube to form an air passage between adjacent heat transfer plates, the heat transfer plate being provided with a plurality of louvers at certain intervals along the air passage, whereby air passing through the air passage exchanges heat with refrigerant passing through the heat exchanging tubes,

wherein a windward side edge of the heat transfer plate and that of the louver are respectively formed so as to become thinner toward a windward side of the air.

In this heat transfer fin according to the ninth aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the ninth aspect of the present invention, it is preferable to employ the following structure (33).

(33) The heat transfer fin as recited in the aforementioned Item (32), wherein at least one of leeward side edges of the heat transfer plate and the louver is formed so as to become thinner toward a leeward side of the air.

The tenth aspect of the present invention employs the following structure (34).

(34) A heat transfer fin disposed in a heat exchanging tube through which refrigerant passes, the heat transfer fin comprising a heat transfer plate arranged parallel to a refrigerant passing direction to transfer heat of the refrigerant via the heat transfer plate,

wherein a refrigerant inlet side edge of the heat transfer plate is formed so as to become thinner toward an upstream side of

the refrigerant passing direction.

The tenth aspect of the present invention is directed to an inner fin or the like to be disposed within a heat exchanging tube. In this heat transfer plate, since the refrigerant inlet side edge of the heat transfer plate is formed so as to become thinner toward an upstream side of a refrigerant passing direction, the refrigerant flows smoothly along the external surface of the heat transfer plate without causing turbulence. Thus, the flow resistance of the refrigerant decreases, causing a decreased pressure loss, which in turn results in an enhanced heat transfer rate. As a result, excellent heat exchanging performance can be obtained.

In the tenth aspect of the present invention, it is preferable to employ the following structure (35).

(35) The heat transfer fin as recited in the aforementioned Item (34), wherein a refrigerant outlet side edge of the heat transfer plate is formed so as to become thinner toward a downstream side of the refrigerant passing direction.

The eleventh aspect of the present invention employs the following structure (36).

(36) A heat transfer fin disposed in a heat exchanging tube through which refrigerant passes, the heat transfer fin comprising a plurality of heat transfer plates arranged parallel to a refrigerant passing direction, the heat transfer plates being provided with openings in a zigzag form to transfer heat of the refrigerant via the heat transfer plates,

wherein a side edge of the opening of the heat transfer plate facing an upstream side of the refrigerant passing direction is

formed so as to become thinner toward the upstream side of the refrigerant passing direction.

In this heat transfer fin according to the eleventh aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the eleventh aspect of the present invention, it is preferable to employ the following structure (37).

(37) The heat transfer fin as recited in the aforementioned Item (36), wherein a side edge of the opening of the heat transfer plate facing a downstream side of the refrigerant passing direction is formed so as to become thinner toward the downstream side of the refrigerant passing direction.

The twelfth aspect of the present invention employs the following structure (38).

(38) A heat transfer fin disposed in a heat exchanging tube through which refrigerant passes, the heat transfer fin comprising a plurality of heat transfer plates arranged parallel to a refrigerant passing direction, the heat transfer plates being provided with openings in a zigzag form to transfer heat of the refrigerant via the heat transfer plates,

wherein a refrigerant inlet side edge of the heat transfer plate is formed so as to become thinner toward an upstream side of the refrigerant passing direction, and

wherein a side edge of the opening of the heat transfer plate facing the upstream side of the refrigerant passing direction is formed so as to become thinner toward the upstream side of the

refrigerant passing direction.

In this heat transfer fin according to the twelfth aspect of the present invention, in the same manner as mentioned above, decreasing the pressure loss and enhancing the heat transfer rate can be attained.

In the twelfth aspect of the present invention, it is preferable to employ the following structures (39) and (40).

(39) The heat transfer fin as recited in the aforementioned Item (38), wherein a refrigerant outlet side edge of the heat transfer plate is formed so as to become thinner toward a downstream side of the refrigerant passing direction.

(40) The heat transfer fin as recited in the aforementioned Item (38) or (39), wherein a side edge of the opening of the heat transfer plate facing a downstream side of the refrigerant passing direction is formed so as to become thinner toward the downstream side of the refrigerant passing direction.

The heat transfer fins according to the first to twelfth aspects of the present invention can be preferably applied to heat exchangers, evaporators for use in car air-conditioners, or evaporators for use in car air-conditioners, as shown in the following structures (41) to (43).

(41) A heat exchanger equipped with a heat transfer fin as recited in any one of the aforementioned Items (1) to (40).

(42) An evaporator for use in car air-conditioners, the evaporator being equipped with a heat transfer fin as recited in any one of the aforementioned Items (1) to (40).

(43) A condenser for use in car air-conditioners, the

condenser being equipped with a heat transfer fin as recited in any one of the aforementioned Items (1) to (40).

Brief Description of Drawings

Fig. 1 is a schematic partially broken perspective view showing a fin portion and therearound of an evaporator according to an embodiment of the present invention.

Fig. 2 is an enlarged cross-sectional view taken along the line P-P in Fig. 1.

Fig. 3 is an enlarged cross-sectional view showing the portion surrounded by the dashed line in Fig. 2.

Fig. 4 is an enlarged cross-sectional view showing a windward side edge of a heat transfer plate/louver of a heat transfer fin according to a first modification of the present invention.

Fig. 5 is an enlarged cross-sectional view showing a windward side edge of a heat transfer plate/louver of a heat transfer fin according to a second modification of the present invention.

Fig. 6 is an enlarged cross-sectional view showing a windward side edge of a heat transfer plate/louver of a heat transfer fin according to a third modification of the present invention.

Fig. 7 is an enlarged cross-sectional view showing a windward side edge of a heat transfer plate/louver of a heat transfer fin according to a fourth modification of the present invention.

Fig. 8 is a graph showing the relationship of the pressure drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 1 and Comparative Example 1.

Fig. 9 is a graph showing the relationship of the pressure

drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 2 and Comparative Example 1.

Fig. 10 is a graph showing the relationship of the pressure drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 3 and Comparative Example 1.

Fig. 11 is a graph showing the relationship of the pressure drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 1 and Comparative Example 2.

Fig. 12 is a graph showing the relationship of the pressure drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 4 and Comparative Example 2.

Fig. 13 is a graph showing the relationship of the pressure drop and the heat transfer rate with respect to the face velocity of evaporators according to Example 1 and Comparative Example 4.

Fig. 14 is a cross-sectional view showing a windward side edge of a louver of a corrugated fin for conventional evaporators.

Best Mode for Carrying Out the Invention

The present invention will be described in detail with reference to the attached drawings.

Fig. 1 is a schematic partially broken perspective view showing a fin portion and therearound of an evaporator for use in car air-conditioners according to an embodiment of the present invention. Fig. 2 is a schematic cross-sectional view of a fin corresponding to a cross-section taken along the line P-P in Fig. 1. In the following explanation, the disposed direction of the heat exchanging tube 51 and 52 will be regarded as an up-an-down direction

for easy understanding of the present invention.

As shown in Figs. 1 and 2, a plurality of heat exchanging tubes 51 and 52 each extending in the up-and-down direction (i.e., vertical direction) are disposed in parallel at a certain distance in the right-and-left direction to form two rows, i.e., fore and aft rows. Disposed between the heat exchanging tubes 51 and 52 adjacent in the widthwise direction of the evaporator is a corrugated fin 53.

The corrugated fin 53 is provided with a plurality of thin plate-like louver fins 54 as transfer plates extending in the fore and aft direction and disposed in parallel at certain intervals in the up-and-down direction. The adjacent louver fins 54 are connected in turns to form a meandering shape. Between the adjacent louver fins 54 and 54 of the corrugated fin 53, an air passage 56 extending in the fore and aft direction is formed. At the operational status, air A introduced from the front side of the evaporator passes through each air passage 56 and flows out of the rear side thereof.

Each louver fin 54 is provided with a plurality of cut-and-bent louvers 55 at certain intervals in the fore and aft direction.

Fig. 3 is an enlarged cross-sectional view showing the portion surrounded by the dashed line Q in Fig. 2. In other words, Fig. 3 is an enlarged cross-sectional view of the front edge 55a of each louver 55, i.e., the windward side edge (air inlet side edge) relative to the air A to be introduced into the air passing passage 56. As shown in Fig. 3., the windward edge 55a of the louver 55 is formed so as to become thinner toward the windward side. Concretely, the windward side edge 55a of the louver 55 is formed into a curved

cross-sectional shape with a rounded tip end, or a semielliptic shape formed by dividing an ellipse along the minor axis.

In this embodiment, the front edge 54a of the louver fin 54 which is a portion surrounded by the dashed line R in Fig. 2, i.e., the windward side edge (air inlet side edge) of the louver fin 54, is formed so as to become thinner toward the windward side as shown by the reference numeral in parentheses in Fig. 3 in the same manner as the aforementioned windward side edge 55a of the louver 55.

As a method for forming the front edge 54a and 55a of the fin 54 and the louver 55, chemical processing such as etching as well as mechanical processing such as pressing, cutting or sharpening can be employed.

In this evaporator, air A is introduced into each air passage 56 from the front side of the evaporator and flows out of the rear side thereof. The air A exchanges heat with the refrigerant passing through each heat exchanging tube 51 and 52 while passing through each air passage.

In this embodiment, the air A to be introduced in the air passage 56 flows smoothly along the external surface of the windward side edge 55a of the louver 55 without causing air turbulence in stead of colliding against the windward side edge 55a because of the tapered semielliptic configuration thereof. Similarly, at the windward side edge 54a of the louver fin 54, the air A flows smoothly along the external surface of the edge 54a without causing air turbulence.

Since the air A flows smoothly without causing air turbulence, the air resistance and the pressure loss decreases, causing an

enhanced heat transfer rate, which in turn results in excellent heat exchanging performance.

In the aforementioned embodiment, although the cross-sectional contour configuration of the front edge 54a/55a of the fin 54/louver 55 is formed into a semielliptic shape, in the present invention, the configuration is not limited to the above embodiments. For example, the cross-sectional contour configuration of the front edge can be a semicircular shape as shown in Fig. 4, an isosceles triangular shape with an acute front edge as shown in Fig. 5, a triangular shape with a single cut side as shown in Fig. 6, and a polygonal shape such as a trapezoidal shape with a tapered end portion as shown in Fig. 7. Furthermore, the configuration can be any combination of the aforementioned shapes shown in Figs. 3 to 7. In short, it can be acceptable so long as the front edge 54a/55a is formed so as to become thinner toward the tip end (windward side end).

In the aforementioned embodiments, all of the louvers 55 are formed to have a tapered front edge 55a respectively. However, in the present invention, it can be acceptable that at least one of the louvers 55 is formed to have a tapered front edge 55a. Furthermore, in the aforementioned embodiments, both fins 54 and louvers 55 are formed to have a tapered front edge 54a and 55a respectively. However, in the present invention, it can be acceptable that at least one of the fin front edge 54a and the louver front edge 55a is formed to have a tapered edge.

Furthermore, in the aforementioned embodiments, the explanation is directed to the case in which the present invention

is applied to an evaporator. However, the present invention is not limited to the above embodiments, and can be similarly applied to heat exchangers such as condensers, heater cores and radiators. Furthermore, such heat exchangers are not limited to heat exchanger for use in car air-conditioners, but can also be applied to heat exchangers for use in room air-conditioners, refrigerators, another refrigeration apparatuses, heaters, etc.

Furthermore, in the aforementioned embodiments, the explanation is directed to the case in which the present invention is applied to a corrugated fin as an example. However, the present invention is not limited to the above embodiments, but can also be applied, for example, to plate fins as independent heat transfer plates to be disposed at certain intervals or skived fins formed by skiving an external peripheral wall(s) of a heat exchanging tube.

Furthermore, in the aforementioned embodiments, the explanation is directed to the case in which the present invention is applied to fins for transferring heat with air. However, the present invention is not limited to the above embodiments, but can also be applied to any fins for transferring heat with another heat transfer medium such as refrigerant.

For example, in cases where the present invention is applied to inner fins for transferring heat with refrigerant, the refrigerant inlet side edge of the heat transfer plate (fin) to be disposed in a heat exchanging tube is formed so as to become thinner toward the upstream side of the refrigerant.

Furthermore, the present invention can be applied to offset fins with heat transfer medium mixing openings formed in summit and

valley portions of a wavy heat transfer plate in a staggered manner. Furthermore, the side edge of the opening of the offset fin facing the upstream side of the heat transfer medium flowing direction among the peripheral edge of the opening can be formed so as to become thinner toward the upstream side.

In the aforementioned embodiments, the front side edge (upstream side edge with respect to the heat transfer medium flowing direction) of the fin (heat transfer plate) or its louver is formed into a tapered configuration. However, the present invention is not limited to the above. For example, the rear side edge (the downstream side edge with respect to the heat transfer medium flowing direction, the heat transfer medium outlet side edge, or the leeward side edge) of the fin (heat transfer plate) or its louver can be formed so as to become thinner toward the rearward side (the downstream side, the outlet side or the leeward side). Furthermore, in the aforementioned offset fin, the side edge of the opening of the offset fin facing the downstream side of the heat transfer medium flowing direction among the peripheral edge of the opening can be formed so as to become thinner toward the downstream side.

(Example)

Hereinafter, examples related to the present invention will be explained.

In accordance with the aforementioned embodiments, evaporators provided with corrugated fins having various types of plural louvers were examined.

<Example 1>

In Example 1, prepared was an evaporator provided with

corrugated fins as shown in Fig. 3 in which the windward side edge of each fin and the windward side edge of each louver were respectively formed into a semielliptic configuration.

Regarding this evaporator, the heat transfer rate and the pressure loss with respect to the face velocity were measured by computer simulation.

As Comparative Example 1, prepared was an evaporator provided with conventional corrugated fins as shown in Fig. 14 in which the windward side edge of each fin and the windward side edge of each louver were respectively formed into a rectangular cross-sectional shape perpendicular to the air flow direction. In Comparative Example 1, the same measurements as in Example 1 were carried out.

These measured results are shown in Fig. 8 in which the solid line denotes Example 1 and the dashed line denotes Comparative Example 1. As will be apparent from this graph, the evaporator of Example 1 is smaller in pressure loss, higher in heat transfer rate and therefore excellent in heat exchanging performance as compared to Comparative Example 1. Especially, Example 1 is excellent in performance at higher face velocity.

<Examples 2 and 3>

In Example 2, prepared was an evaporator provided with corrugated fins as shown in Fig. 4 in which the windward side edge of each fin and the windward side edge of each louver were respectively formed into a semicircular cross-sectional shape.

In Example 3, prepared was an evaporator provided with corrugated fins as shown in Fig. 5 in which the windward side edge of each fin and the windward side edge of each louver were

respectively formed into an isosceles triangular cross-sectional shape.

Regarding evaporators of Examples 2 and 3, the same measurements as in Example 1 were carried out. The measured results are shown in the graphs shown in Figs. 9 and 10. Each of the graphs also shows the measured results of the evaporator of Comparative Example 1.

As shown in these graphs, the evaporator of Example 2 is smaller in pressure loss, higher in heat transfer rate and therefore excellent in heat exchanging performance as compared to Comparative Example 1. Furthermore, Example 3 is excellent in heat transfer rate especially at higher face velocity and therefore excellent in heat exchanging performance, though no superiority can be recognized in pressure loss.

<Comparative Example 2>

In Comparative Example 2, prepared was an evaporator provided with corrugated fins in which the windward side edge of each fin and the windward side edge of each louver were respectively formed into a rectangular cross-sectional shape (see Fig. 14), and the leeward side edges thereof were respectively formed into a semielliptic cross-sectional shape as shown in Fig. 3.

Regarding this evaporator, the same measurements as in Example 1 were carried out. The measured results are shown by the dashed line in the graph shown in Fig. 11. In this graph, the solid lines denote the measured results of the evaporator of Example 1.

This graph reveals the fact that the evaporator of Example 1 is smaller in pressure loss and higher in heat transfer rate as

compared with the evaporator of Comparative Example 2. In other words, forming the windward side edge among both side edges of the fin/louver into a tapered end enhances heat transferring performance as compared with the case in which the leeward side edge is formed into a tapered end.

<Example 4>

In Example 4, prepared was an evaporator provided with corrugated fins in which the windward and leeward side edges of each fin and the windward and leeward side edges of each louver were respectively formed into a semielliptic cross-sectional shape as shown in Fig. 3.

Regarding this evaporator, the same measurements as in Example 1 were carried out, and the measured results are shown in Fig. 12. In this graph, the dashed lines denote the measured results of the evaporator of Comparative Example 2.

This graph reveals the fact that forming both edges of each fin/louver into a tapered edge respectively can enhance the heat exchanging performance as compared with the case in which only one leeward side edge is formed into a tapered edge.

Fig. 13 shows the measured results of Example 4 with solid lines and the measured results of Example 1 with dashed lines.

The graph reveals that the evaporator of Example 4 is slightly small in pressure loss and slightly higher in heat transfer rate as compared with Example 1. In other words, forming both side edges of the fin/louver into a tapered end respectively enhances heat transferring performance as compared with the case in which only one windward side edge is formed into a tapered end.

As explained above, according to the present invention, since a heat transfer medium inlet side edge of a heat transfer plate and/or its louver is formed into a tapered end, a heat transfer medium such as air can flow along the external periphery of the heat transfer plate and/or its louver, causing smooth flow without no turbulence. Accordingly, heat transfer medium flow resistance and pressure loss can be decreased, causing an enhanced heat transfer rate, which in turn results in excellent heat exchanging performance.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intent, in the use of such terms and expressions, of excluding any of the equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

Industrial Applicability

The present invention can be applied to, for example, a heat transfer fin for heat exchangers such as evaporators or condensers for use in car air-conditioners, and also relates to a heat exchanger, an evaporator for use in car air-conditioners or a condenser for use in car air-conditioners using such heat transfer fins.